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Energy Efficiency in the Western Balkans: The Case of Kosovo

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Abstract

In light of the growing energy demands and the need for sustainable development, this study aims to assess the current state of Kosovo's energy system and evaluate potential pathways for its modernization and integration into the European energy market. The case study analysis was carried out to contextualize the emergence and development of the Western Balkans' energy system and suggest strategies for its improvement, with a special focus on the Republic of Kosovo. The case study analysis was guided by industry reports and peer-reviewed journal articles published since 2020 and selected based on their relevance and credibility. The contextual assessment revealed that after Yugoslavia's breakup in the early 1990s, its former members inherited a fragile and outdated system that did not meet quality and safety standards. The cost-benefit analysis, which was carried out as a part of this study, revealed that the potential advantages of modernizing Kosovo's energy system and integrating it into the pan-European market outweigh existing limitations. The identified benefits included accelerated economic growth, as reflected in the gross domestic product; rapid industrialization and urbanization of the country; participation in the European Union projects aimed at diversifying the energy portfolio, creating new jobs, and shifting toward clean energy sources; and liberalization of the energy sector to improve the quality of services received by different population groups and sectors of the economy. To take advantage of the mentioned benefits, the Republic of Kosovo recommended several short-term, mid-term, and long-term interventions, including efficient use of electricity to reduce demand, diversification from lignite coal, and a shift towards renewable energy sources.

Keywords

Yugoslavia's breakup; Electricity tariff system; Lignite coal; Renewable energy sources; Kosovo Energy Corporation

Introduction

A period of political and economic crisis in the 1980s brought to the surface a series of unresolved inter-ethnic conflicts, leading to the breakup of the Socialist Federal Republic of Yugoslavia. The six republics, namely, Bosnia and Herzegovina, Croatia, Macedonia, Montenegro, Serbia (with Kosovo and Vojvodina included), and Slovenia, faced a repertoire of challenges, including the provision of a reliable energy supply. Years after the breakup of Yugoslavia, the Western Balkan region, composed of Albania, Bosnia and Herzegovina, Croatia, Macedonia, Montenegro, Serbia, and Kosovo, has an energy system that can be described as fragile and in need of investment.

Low efficiency of the energy system is a cause of concern since it can trigger a range of economic, environmental, and social issues (Capasso *et al*., 2021; Ismayilov *et al*., 2021). In particular, a stable supply of energy is the driving force of the economy, where new workplaces are generated, thousands of people are lifted out of poverty, and socioeconomic discrepancies are addressed. An efficient energy system supports cross-cultural cooperation, as foreign investors consider stability as a crucial factor when deciding to enter a particular country. Furthermore, an effective energy system preconditions a more active and efficient use of alternative energy sources to support the nation's sustainable development. Therefore, it is essential to examine the factors affecting energy efficiency in the Western Balkans, including Kosovo, and suggest evidence-based response strategies.

According to the Office of the Historian (2024), Kosovo has been an independent state since February 17, 2008, when it declared its separation from Serbia, and its political status was recognized by most European countries, the United States, Japan, Canada, and some African and Asian countries. The newly formed republic faces a repertoire of issues, including insufficient security of electrical supply, resulting in blackouts affecting the economy and reducing the quality of life. As stated by the International Energy Agency and United Nations Development Programme (2008), the challenge facing Kosovo is also relevant to other Western Balkan countries because the conflicts over the break-up of Yugoslavia damaged much of the energy infrastructure, whose recovery takes time and is expensive. Based on the Energy Strategy of the Republic of Kosovo Report 2022-2031 (Government of Kosovo, 2022), the challenges can be addressed by integrating Kosovo's power system into the regional and pan-European market. Frey (2024) suggested supporting the independence of the national energy system through reliance on renewable energy sources, such as wind energy, solar energy, or hydropower.

Strategies aimed at boosting the national energy sector are rooted in an in-depth understanding of the realities both in Kosovo and in the region as a whole. The research carried out by Feldhaus and Stiewe (2021) revealed that coal is the main source of energy supply in the country since coal power plants account for roughly 97% of all electricity produced. Cimmino and Vicidomini (2024) explained that while coal is relatively cheap, high dependency on this energy source causes environmental pollution and triggers a range of health problems. This idea was elaborated by Michalak, Matkovic and Stauffer (2023), who examined the environmental and health consequences of the Polish energy system's dependence on coal. By using Poland as a case study, the experts discovered

that with 72% of electricity produced from coal combustion, the country generated CO_2 emissions that were three times higher than the European Union average. The statistics encourage taking a closer look at the environmental and health issues persistent in Kosovo, whose heavy reliance on coal combustion for energy production has not yet been inspected.

However, it is possible to hypothesize that Kosovo's reliance on coal combustion will persist shortly as the country's final energy demand has roughly doubled since 2000 (Feldhaus and Stiewe, 2021; Prokopov *et al*., 1992). Bechev (2023) attributed this growing demand to Kosovo's rapid industrialization and urbanization preconditioned by its commitment to becoming part of the Western economic space. In turn, Krasniqi and Ymeri (2022) pointed out that failure to promptly address the growing energy demand can bring collapse to the national power supply system, especially if external political, socio-economic, and other factors are not considered.

As stated by Di Bella and Thaci (2023), these factors include a sharp increase in energy prices across Europe and persistent energy market pressures since the start of the war in Ukraine. Emiliozzi, Ferriani and Gazzani (2023) in their work stressed that external factors can exacerbate internal challenges of Kosovo's energy system, including limited flexibility of the national tariff setting framework and the fact that around one-fifth of the national electricity consumption is either not billed or billed but not collected. However, few academic studies approach the internal and external factors preconditioning the sustainable development of Kosovo's energy system.

Considering limited empirical research in the field, this study aimed to assess the Western Balkans' energy system's efficiency, with particular attention paid to Kosovo. The detected aim encompasses several objectives, namely, to analyze internal and external factors shaping the energy system's efficiency; to detect hindrances to the energy system's efficiency; and to suggest strategies to overcome the power supply system's efficiency and precondition its sustainable development.

Methodology

A comprehensive review of the literature was conducted to assess the efficiency and sustainability of Kosovo's energy sector. Sources were gathered from academic databases such as Web of Science, Scopus, and JSTOR, using keywords and phrases including 'energy sector', 'energy efficiency', 'sustainable energy', 'energy policy', 'Kosovo energy market', 'Western Balkans energy infrastructure', 'regional energy integration', 'renewable energy investment', and 'cost-benefit analysis'. The search was further narrowed down to 46 sources by applying the selection criteria of: recency (most sources published in the last five years); relevance (the selected studies are either connected to energy efficiency, Kosovo's energy sector, or both); and credibility (the sources were created by authors whose credentials are easy to identify and verify). Most sources were published within the last five years to ensure the inclusion of the most current research and developments. The selected studies were directly connected to energy efficiency, Kosovo's energy sector, or both, ensuring that the literature was pertinent to the research focus. Credibility was evaluated based on the credentials of the authors, which were easy to identify and verify. Factors such as the impact factor of the

publishing journals and the affiliations of the authors were considered to ensure the reliability of the information.

Further analysis of data sources added to the sample aimed to assess the connection between Kosovo's energy management strategies and the broader regional and global energy markets. The research also incorporated industry reports such as the Annual Implementation Report (2023), Summary for Policymakers of Climate Change 2023 Synthesis Report (Intergovernmental Panel on Climate Change, 2023), Energy Sector Issues in Kosovo (Feldhaus and Stiewe, 2021), and Kosovo's Electricity Sector Challenges and Opportunities (Di Bella and Thaci, 2022). Additional peer-reviewed sources, including Murtezaj *et al*. (2024), Meha, Bresa and Bresa (2024), and Bylykbashi and Filkoski (2023), were included to strengthen the analytical framework.

The initial phase of the study involved analyzing selected reports and articles to set the stage for further discussion. The contextual analysis was conducted to elaborate on the historical, political, and socio-economic factors preconditioning the emergence and development of the Western Balkans' energy system, with a special focus on Kosovo. The contextualized factors provided an in-depth understanding of the challenges and prospects of Kosovo's energy system.

The research further utilized a cost-benefit analysis to assess the prospects of integrating Kosovo's energy supply system into the regional and pan-European market. This analysis was primarily informed by peer-reviewed articles that elaborated on the challenges and opportunities of investing in Kosovo's energy supply system. The logic behind the conducted analysis was that opportunities outnumber difficulties, making Kosovo's energy system worth modernizing. The cost-benefit analysis further informed the recommendations to enhance efficiency and support the sustainability of Kosovo's energy supply system.

Thematic analysis was employed to synthesize the data from the literature review and qualitative research. This involved identifying and coding recurring themes related to energy efficiency, sustainability, and public awareness. Themes were categorized based on their relevance to the research objectives, and frameworks such as the Technology-Organization-Environment (TOE) framework were used to structure the analysis. This systematic approach ensured that the findings were robust and aligned with established methodologies in energy policy research.

Results

Kosovo's Energy System in Context

Contextualization helps to gain an in-depth understanding of the challenges and opportunities facing the Kosovo energy system, as well as develop effective responses to these factors. Axyonova and Kartsonaki (2024) admitted that Kosovo's path to independence began in 1912 when Serbia acquired control over the territory during the First Balkan War. After World War II, Kosovo changed its status to an autonomous province of Serbia, and this status was relatively stable until 1991-1992, which was the period of Yugoslavia's breakup. The data collected by the Central Intelligence Office

(CIA) suggests that the year 1998 became the turning point in Kosovo's struggle for independence, as that year, Belgrade launched a counterinsurgency campaign resulting in 800,000 ethnic Albanians expelled from their homes in Kosovo. In response to the failed international mediation, a North Atlantic Treaty Organization (NATO) campaign was launched to force Belgrade to withdraw its troops from Kosovo. In 1999, the United Nations (UN) Security Council Resolution issued a report to endorse Kosovo's independence, which was eventually declared on 17 February 2008. Although Serbia rejects the independence of its former state, Kosovo has established diplomatic, economic, and other relations with a range of countries around the world.

These relations, however, do not make the country immune to the challenges facing its energy system. The report of the Organization for Economic Co-operation and Development (OECD) (2022) underlined a repertoire of tasks to accomplish, including the introduction of the European Union (EU) market standards and mechanisms. However, Ignjatovic, Filipovic and Radovanovic (2024) stressed that accomplishing this goal is hindered by the peculiarities of the Western Balkans' energy system. The expert further explained that, except Albania, Yugoslavia's energy sector took the form of an interconnected infrastructure designed to serve the needs of a unified nation. As stated by Trbojevic, Jovanovic and Durdevic (2024), the system involved a thought-out arrangement of reservoirs, power plants, and hydropower stations that operated as a single whole to provide affordable energy in the most sustainable way possible. The breakup of Yugoslavia made the energy system fragmented, meaning that some newly formed states were left without a sufficient energy supply, while others faced its overabundance.

Of the six countries formed after the breakup of Yugoslavia, only Bosnia and Herzegovina exports power and has surpluses, while the other states rely on imports to overcome acute shortages. The data was confirmed by the Energy Strategy of the Republic of Kosovo 2022-2031 Report (Government of Kosovo, 2022), according to which the country's consumption of electricity has doubled over the past decade. The experts attribute this increase to the industrial growth and urbanization facing the former members of Yugoslavia. Frey (2024) attributes the growing demand for energy to the building sector, which has become the major driver of the Western Balkans' economy. The expert emphasized that in the Western Balkans region, the building sector accounts for around 60% of the total electricity consumption, which significantly exceeds the European average. The building sector's energy consumption rates are compared in figure 1.

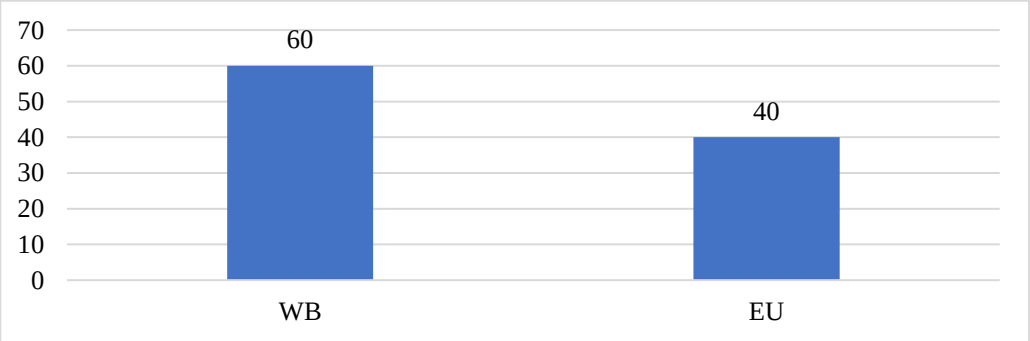

Figure 1: Energy consumption of the building sector in the Western Balkans (WB) and European Union (EU) in % of total energy consumption [*Source:* Frey (2024)]

Based on collected evidence, the building sector will continue driving the national economy and remain the major consumer of the energy produced. Hence, the priority task facing the Republic of Kosovo is to ensure that the energy is sufficient and comes at an affordable price.

However, accomplishing this goal might be hindered by several factors, including the monopolization of the national electricity market. The existing data suggests that most electricity companies in the Western Balkans region are state-owned companies that also act as electricity transmission systems. As explained by Frey (2024), these enterprises hold regular auctions at which they sell cross-border transfer capacities. In turn, the Annual Implementation Report (2023) emphasizes that 93% of all the electricity produced in the region is transmitted by eight companies, three of which are located in Bosnia and Herzegovina, and the remaining are equally distributed across the five states. The current state of the energy sector in the Western Balkans region is shown in figure 2.

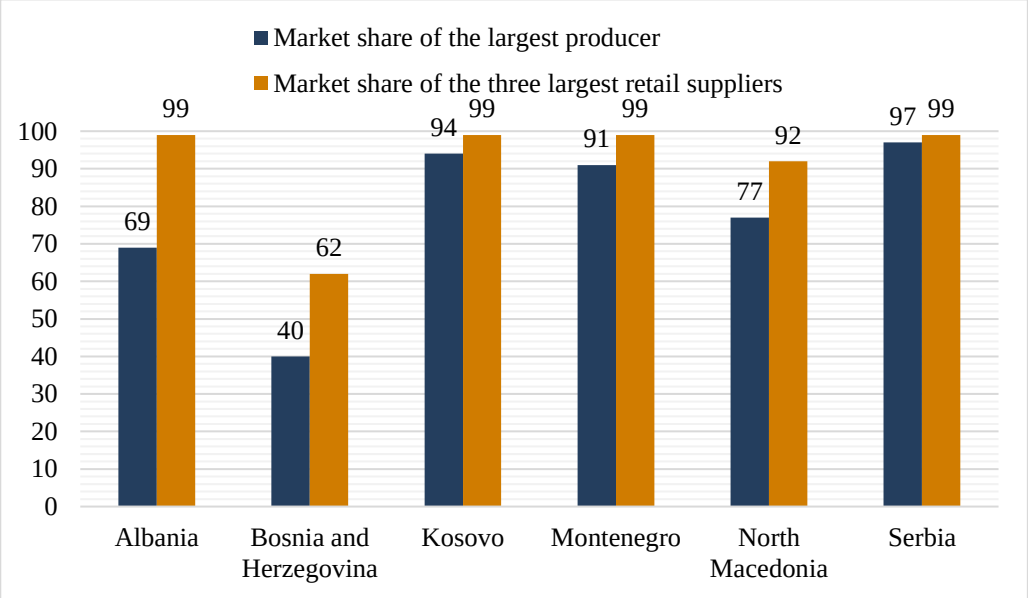

Figure 2: Market share in the wholesale and retail electricity market [*Source*: Frey (2024), Annual Implementation Report (2023)]

The figure suggests that, compared to other countries in the region, including Albania, Bosnia and Herzegovina, or North Macedonia, Kosovo's energy sector is characterized by a high level of monopolization. This conclusion is rooted in the fact that in the Republic of Kosovo, the market share of the largest producer is almost equal to the market share of the three largest retail suppliers.

Liberalization of the national energy sector could attract smaller companies, improve the quality of service, and facilitate the market's operation in line with the EU standards (Deryaev, 2024a; Kubiczek *et al.*, 2023). However, this would also result in price deregulation and fluctuation, at least during the initial phase of the transition process. Therefore, it is possible to assert that the monopoly of the national energy sector will continue for some time in the future.

Another issue facing Kosovo after Yugoslavia's breakup is the deterioration of its energy infrastructure, which hinders the transmission of the generated electricity. Frey (2024) emphasized that several EU-sponsored projects were put in place to modernize the system, improve the utilization of its capacities, and facilitate better absorption of electricity generated from renewable energy sources (RES). Some projects to consider are the 400-kW line between Kosovo and Albania, the Fier-Vlora gas pipeline, the Trans-Adriatic Pipeline, and the Trans-Balkan Electricity Transmission Corridor. While all these projects imply a repertoire of benefits for Kosovo's energy supply system, they are quite resource-intensive, time-consuming, and rely heavily on using coal and gas as the major environmental pollutants.

Therefore, it is possible to assert that the breakup of Yugoslavia affected Kosovo's energy supply system, which is closely integrated into the Western Balkans system. The challenges facing the national energy sector were exacerbated by the swift industrialization and urbanization, resulting in a growing demand for electricity across various sectors of the economy. Efforts have been made to modernize the energy production and distribution system; however, the process is resource-intensive, takes time, and is impossible without external assistance.

Cost and Benefit Analysis

A cost-benefit analysis was carried out to inform the need for modernizing Kosovo's energy supply system. The results are summarized in table 1.

Table 1: Cost and benefit analysis of modernizing Kosovo's energy supply system

No.	*Costs*	*Benefits*
1	Energy prices have increased across Europe.	Economic growth will accelerate as expressed in gross domestic product (GDP).
2	High uncertainty of the global energy market preconditions price volatility	The energy demand has doubled in the last decade and will continue to grow due to industrialization and urbanization.
3	Heavy reliance on coal as the primary source of energy generates pollution.	Kosovo's energy system becomes integrated into the regional and pan-European market.
4	Low public awareness hinders the implementation of RES	The EU-sponsored projects facilitate the transition to the use of RESs.
		Liberalization of the energy sector improves the services provided.
		Stable energy sector attracts investors, including foreign ones.
		The national tariff framework is sound and facilitates the provision of affordable energy to different sectors of the economy.

Source: Di Bella and Thaci (2023), Feldhaus and Stiewe (2021), World Bank Group (2023).

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In terms of the cost and benefit analysis, perspectives outweighing challenges confirm the feasibility of modernizing Kosovo's energy supply system. However, a closer look at the detected costs and benefits is needed to inform effective transformation strategies. Stable economic growth is among the major preconditions for modernizing Kosovo's energy system. The data collected from the World Bank Group (2023) suggests that after a short period of decline, which was mainly caused by the coronavirus-related restrictions, Kosovo's economy has resumed its growth. The dynamics are shown in table 2.

Table 2: Kosovo's real GDP growth in % as compared to other WB countries

Real GDP Growth (%)	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*
Kosovo	-5.3	10.7	5.2	3.2	3.9	4.0
Albania	-3.3	8.9	4.8	3.6	3.2	3.2
Bosnia and Herzegovina	-3.0	7.4	3.9	2.2	2.8	3.4
North Macedonia	-4.7	3.9	2.1	1.8	2.5	2.9
Montenegro	-15.3	13.0	6.4	4.8	3.2	3.1
Serbia	-0.9	7.5	2.3	2.0	3.0	3.8

Source: World Bank Group (2023)

The table suggests that despite a considerable decline in 2020, the Republic of Kosovo demonstrated a quick recovery and stable economic growth. The indicated dynamics are considered an opportunity because part of the generated profit can be redirected to modernizing the national energy infrastructure. Furthermore, stable economic growth attracts foreign investors who contribute to the restoration and modernization of Kosovo's energy system to ensure its operation in line with the EU standards.

Another prospect to consider is the growing demand for electricity caused by swift industrialization and urbanization during the post-breakup era. The data collected by Feldhaus and Stiewe (2021) indicated a twofold increase in the electricity consumption over the past decade. Furthermore, evidence collected from Feldhaus and Stiewe (2021) is consistent with the data introduced by Frey (2024) and suggests that the residential sector is the major consumer of energy in the Republic of Kosovo. The energy consumption statistic by sector is shown in figure 3.

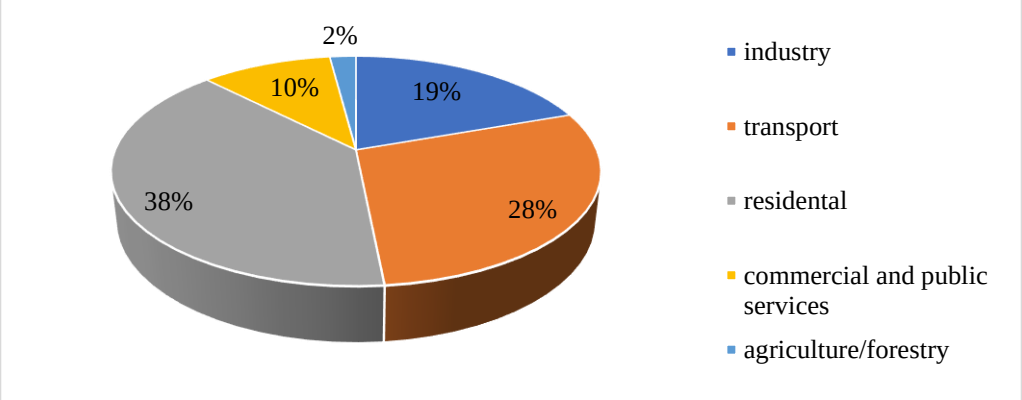

Figure 3: Electricity consumption by sector [*Source:* Feldhaus and Stiewe (2021)

The diagram suggests that energy consumption rates across major sectors of the economy in the Republic of Kosovo are similar to those in the EU's average. The detected fact indicates the opportunities for integrating Kosovo's energy system into the pan-European space. In addition to the aforementioned benefits, the Republic of Kosovo might benefit from the EU-sponsored projects aimed at modernizing its energy system. The most notable projects are documented in table 3.

Table 3: EU-sponsored projects aimed to modernize Kosovo's energy system's efficiency

No.	*Project*	*Overview*
1	Ionian-Adriatic gas pipeline	Diversification of gas supply to WB and other regions.
2	Fier-Vlora gas pipeline	Part of the Trans Adriatic Pipeline (TAP) project connecting the Trans Anatolian Pipeline and the Greek-Turkish border.
3	North Macedonia-Greece interconnector	Extends gas links between North Macedonia and Kosovo.
4	Trans-Balkan Electricity Transmission Corridor	Facilitates the distribution of electricity throughout the WB and to the EU.

Source: Frey (2024)

These are just some projects illustrating foreign investors' interest in modernizing the Republic of Kosovo's energy supply system to facilitate its alignment with the EU standards. Furthermore, a considerable benefit might come from liberalizing the country's energy sector and increasing the flexibility of its tariff-setting framework. Feldhaus and Stiewe (2021) in their report, argued that the existing tariff framework is overall sound as tariffs are set once per year and consider a repertoire of factors shaping price generation. However, it is also worth stressing that the tariff system is not flexible enough to address changes at the state and international levels. The case illustrating this assumption involves the Energy Regulatory Office's (ERO) refusal to increase tariffs in 2022 following the start of the war in Ukraine and energy market pressures in Europe. The ERO experts argued that government subsidies to the sector were sufficient to finance the difference between import electricity prices and prices recognized in tariffs.

Efforts to increase the tariff system's flexibility might help the Republic of Kosovo to overcome a repertoire of challenges associated with the modernization of the national energy sector, such as the growing energy prices across Europe. Feldhaus and Stiewe (2021) attributed the growing prices to the changes gripping the European market first in winter 2021-2022 and then in summer 2022. The changes challenged the Kosovo energy system, which used to rely on relatively low European electricity prices, making it possible for the sector to operate without major fiscal losses. Presently, the system is to maintain a balance between aligning to the EU standards and keeping tariffs affordable for the major sectors of the national economy.

In addition to the aforementioned costs, it is worth considering that Kosovo's energy sector remains the major source of environmental pollution that, combined with low public awareness on the matter, can trigger a range of difficult-to-handle

consequences. Knitter and Kammen (2023) reported that despite some progress in the sector, coal remains the major source of energy, which contributes to abnormal CO_2 emission rates. Based on available evidence, coal plants account for 54% of CO_2 emissions in the energy sector, which are five times the EU average. Meanwhile, the transition to RES is a costly and lengthy process that might be hampered by low public awareness of the consequences of using coal as the main source of energy. The environmental burden results in considerable public health repercussions. Recent data from the Republic of Kosovo indicate that respiratory ailments, including chronic bronchitis and asthma, are 2.5 times more prevalent in municipalities near coal combustion sites, such as Obiliq and Drenas, relative to the national average (The Ministry of Health of Kosovo, 2022). Moreover, Belis *et al*. (2023) assessed that particulate matter ($PM_{2.5}$) levels in these regions are often above permissible limits, leading to heightened morbidity and mortality rates. These data emphasise the critical necessity of shifting to greener energy sources, both as an environmental obligation and as a public health measure. Incorporating dependable renewable energy sources (RESs) will substantially decrease exposure to air pollution and alleviate the long-term health expenses currently incurred by the most susceptible demographic groups (Hamidova, Huseynov and Samadova, 2022; Serikuly *et al*., 2022).

Hence, the cost and benefit analysis revealed that the opportunities of modernizing Kosovo's energy system significantly outnumber potential limitations, which encourages efforts at integrating into the regional and pan-European space. A closer look into the benefits associated with such integration provides insights into the strengths which the Republic of Kosovo can build to ensure stable energy generation and fair distribution across sectors. In turn, analysis of costs and limitations informs effective responses to the instances when Kosovo's energy system faces volatility at the national and international levels.

Recommendations to Increase the Kosovo Energy System's Efficiency

The cost and benefit analysis also revealed that while some interventions might be effective in the short and medium term, others can generate positive changes in the long run. Hence, recommendations can be divided into three groups as shown in figure 4.

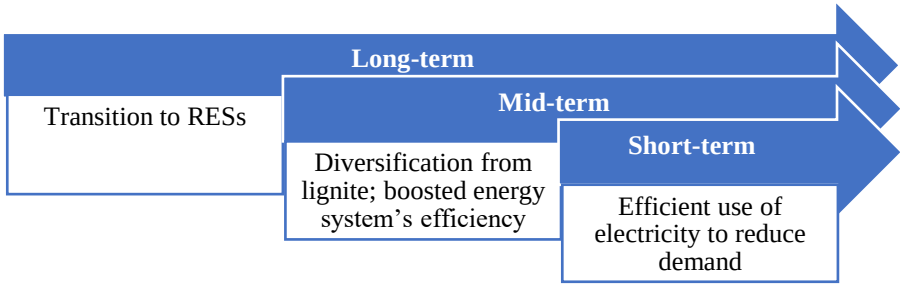

Figure 4: Transformations in Kosovo's energy system

In the short term, it is recommended to facilitate efficient use of electricity to reduce demand and contribute to balance in the energy system (Tagybayev *et al*., 2023; Telbayeva *et al*., 2024). This recommendation is rooted in the study of Feldhaus and Stiewe (2021) examining three possible scenarios, namely, a 50% increase in the external price of electricity; a 10% decrease in Kosovo Energy Corporation's electricity production; and a 20% increase in the external price of electricity passed through domestic tariffs. The experts discovered that while these scenarios will affect all sectors and population groups, the most devastating effects will be experienced by vulnerable households. The latter, however, are not immune to the negative effects of price increases, especially if those are abrupt. Feldhaus and Stiewe assert that under such a scenario, the least protected households go through liquidity choke points, resulting in load shedding. Considering the mentioned effects, a more effective response would be increasing the frequency of tariff adjustments while encouraging efficient energy use. Such use implies differential increases in peak-hour consumption for non-vulnerable consumers and reduced fiscal cost of subsidies.

The recommended mid-term intervention involves diversification from lignite to boost the energy system's efficiency. The data provided by the International Trade Administration (2024) asserted that Kosovo has one of the world's largest lignite-coal reserves, which makes the country a significant exporter and reliable partner. The Federal Ministry for Economic Cooperation and Development (2022) elaborated on the idea by arguing that 90% of the energy consumed in the Republic of Kosovo is generated from lignite coal. Nevertheless, heavy reliance on this energy source causes concerns among experts who highlight the high level of air pollution as compared to the UE average rates. The conclusion is rooted in the study of Bajra-Brahimaj *et al*. (2024), who used oxidative stress biomarkers and biochemical indicators to confirm the high rates of CO_2 emissions caused by the use of lignite coal to produce energy. In turn, Belis *et al*. (2023), Chen-Xu *et al*. (2024), and Ukëhaxhaj *et al*. (2024) pointed to the statistically significant correlation between CO_2 emission rates and public health issues, especially respiratory diseases and various forms of cancer. Hence, the Republic of Kosovo faces the complex task of maintaining the balance between adhering to the EU CO_2 emission reduction standards and providing different sectors of its economy with affordable energy. This task can be partly addressed through the diversification from lignite, which involves cooperation with the EU toward achieving sustainability goals.

As for the long-term goals, the Republic of Kosovo is recommended to shift to using renewable energy sources, the effectiveness of which has already been confirmed by several studies conducted in the country. In particular, the study of Bylykbashi and Filkoski (2023) confirmed that due to its geographic location, the Republic of Kosovo has enough solar energy that can partly cover its electricity needs. Based on collected data, the highest energy produced for real conditions during summer months was 2811.86 kWh, while the highest maximum power point (MPP) voltage produced during the same period was 400 V. The data means that due to the Mediterranean atmospheric conditions, the Republic of Kosovo can cover its clean energy needs, at least in the summer. In turn, the data collected from Prizren, a city in the south part of the country with a population of approximately 90,000 inhabitants and an area of 640 km2, confirmed that in some parts of the republic, wind and hydropower can be used as alternative energy sources (Rubino and Rubino, 2019; Zhangabay *et al*., 2023). The

calculations carried out for a 50-year lifetime project suggest that the integration of RESs into the existing energy system will enable the region to cope with existing load fluctuations in demand while reducing CO_2 emission rates to the EU-approved levels. In turn, Meha, Bresa, Bresa (2024) discovered that the integration of RESs might be facilitated by the electrification of the heating and transport sectors that consume a considerable part of the total energy produced.

Therefore, strategies to increase the Republic of Kosovo's energy system's efficiency incorporate short-term, medium-term, and long-term goals. The country is recommended to start the transformation process by increasing energy efficiency at the household level, through the diversification of its energy portfolio, and toward a greater reliance on RESs as a part of its sustainable development efforts.

Discussion

Based on collected evidence, the breakup of Yugoslavia had a profound impact on the six countries that used to be part of it. The confirmation of this assumption was, for example, found in the study of Gjukaj *et al*. (2024) examining the energy of the Western Balkan energy sector, with a special focus on the Republic of Kosovo. The experts stressed that Kosovo's heavy reliance on a fragile energy sector with inflexible power plants put the country in a vulnerable position, especially during the first years following Yugoslavia's breakup. Several studies, including Gjukaj *et al*. (2024) and International Monetary Fund (2023) Country Report No. 23/200 "Republic of Kosovo: Request for a Stand-By Arrangement and an Arrangement under the Resilience of Sustainability Facility-Press Release" (2023), emphasize that since the early 2000s, the Republic of Kosovo has achieved considerable progress in overcoming the vulnerability of its energy sector. However, much remains to be done to enhance the national energy sector's efficiency.

This study suggests increasing the Kosovo energy system's efficiency through its integration into the regional and pan-European market, which is facilitated by the country's involvement in such projects as the Ionian-Adriatic gas pipeline, the Fier-Vlora gas pipeline, the North Macedonia-Greece interconnector, and the Trans-Balkan Electricity Transmission Corridor. This hypothesis was also tested in previously conducted studies, including Del Mar, Taglioni and Zárate (2023), Marku and Teqja (2024), and Hogic (2024). The former researchers focused on the Western Balkan trade reforms and improvements in road infrastructure that might boost average welfare rates by 6%. In turn, Marku and Teqja (2024), as well as Hogic (2024), introduced a general overview of the integration process by comparing the Open Balkans initiative with the Berlin Process after World War II. By using Albania as a case study, the experts concluded that the local population, especially young people, are overall positive about the integration resting on the revised financial framework and a stronger political approach. Hence, previously accumulated evidence illustrated the significance of the Western Balkan integration into the pan-European market in response to the challenges caused by Yugoslavia's breakup.

Recent advancements in EU energy policy, notably the execution of the European Commission's (2023a) REPowerEU Plan and the European Commission's (2024) Green Deal Industrial Plan, highlight the strategic imperative of synchronizing Kosovo's

energy transition with contemporary European frameworks. The REPowerEU initiative, established in reaction to the volatility in global energy markets due to Russia's invasion of Ukraine, advocates for the diversification of energy sources beyond fossil fuel imports, the expedited investment in renewable energy infrastructure, and the simplification of permitting processes for renewable energy implementation. This is particularly relevant for Kosovo, a nation heavily dependent on lignite and possessing substantial untapped potential in solar, wind, and hydro resources.

The European Commission's (2024) Green Deal Industrial Plan aims to bolster the EU's clean energy competitiveness, highlighting the integration of candidates and surrounding countries into the wider decarbonization framework. Kosovo is poised to gain enhanced access to financial and technical resources, including the Western Balkans Investment Framework and the Energy Community Secretariat's Clean Energy for All Europeans Package, both aimed at facilitating sustainable energy transitions in the region.

In this context, Kosovo's modernization strategy must be adjusted to conform to REPowerEU's objectives for renewable energy implementation, namely regarding rooftop solar systems, the electrification of district heating networks, and the enhancement of electrical grids. The policy must also incorporate Kosovo's involvement in the EU's methane emissions reduction programs, considering the nation's ongoing reliance on lignite. Furthermore, participation in the Green Deal Innovation Fund and the Resilience Facility may enable infrastructure enhancements while tackling ongoing energy poverty. Kosovo's policy planning must align with the goals of the EU's Fit-for-55 legislative package, which aims for a 55% reduction in greenhouse gas emissions by 2030 and establishes a pertinent standard for energy governance in EU candidate countries (European Commission, 2023b).

However, the present study has made a significant contribution to the academic discourse by paying attention to the previously understudied case of Kosovo. Until relatively recently, little has been done to explore the challenges and prospects of Kosovo that some experts, including Mihaylov (2024), tend to examine through Serbia's lens. A solid attempt to examine the energy sector of Kosovo was found in the study of Krasniqi (2023), who confirmed a previously put forward assumption that despite the rich mineral deposits, mainly lignite coal, the country struggles to enhance its energy system's efficiency. The researcher attributed the detected discrepancy to the lack of effective infrastructure and an appropriate strategy for the sector's development. Krasniqi's conclusions are in alignment with previously introduced findings about the Republic of Kosovo's being at a crossroad where it has to keep a delicate balance between adhering to the European standards and requirements and providing its various sectors of the economy and population groups with quality and affordable services (Deryaev, 2024b; Fialko *et al*., 1992).

Failure to maintain this balance might exacerbate inequality that has been the hallmark of the Western Balkan community for decades. Based on collected data, low-income households are the most vulnerable to any changes taking place in Kosovo's energy system, including sharp increases in tariffs. Previously conducted research, including Acheampong, Daztor and Shahbaz (2021) and Sinha *et al*. (2022), confirmed that access to energy preconditions inequality and exacerbates poverty around the world. This

conclusion is also consistent with the findings of Acheampong, Daztor and Shahbaz (2021), rooted in a set of 166 countries where unequal access to energy is considered a critical problem. Sinha *et al*., in particular, stressed the uneven distribution of energy, causing the so-called "energy poverty". Based on the systematic review of 22 studies, Katoch *et al*. (2023) emphasized the growing prevalence of energy poverty, which deprives individuals and population groups of such services as lighting, heating, and even cooking. According to Volodzkiene and Streimikiene (2023), who reviewed a set of 203 articles, including 61 directly focused on energy inequality indicators, interventions to alleviate energy poverty might boost economic development. Considering this, it is critical to ensure that the Republic of Kosovo's energy system is modernized so its capacities are sufficient to provide all sectors economy and population groups with equal access to electricity.

One solution to energy poverty involves transitioning to RESs, which was explored as a long-term intervention in this study. The effectiveness of this recommendation was confirmed in several studies, including Katoch *et al*. (2024), Simionescu *et al*. (2023), and Simionescu, Radulescu and Belascu (2024). The mixed-methods study carried out by Katoch *et al*., which was focused on China, India, and Bangladesh, demonstrated that reliance on solar energy can reduce energy poverty by providing vulnerable population groups with sustainable and comparatively cheap energy.

Simionescu, Radulescu and Belascu (2024) stressed that the use of sustainable energy can also address environmental pollution and healthcare inequality, especially in low and middle-income countries (LMICs). This conclusion was based on the comparative analysis of the pollution levels in 10 Central and Eastern European Countries (CEECs) and EU member states. The comparison revealed a statistically significant positive correlation between energy poverty and CO_2 emission rates, which indicates the significance of introducing RESs, especially in LMICs. However, Simionescu *et al*. (2023) stressed that such implementation might be hindered by a repertoire of factors, such as the lack of financial incentives and technological hindrances. The introduced studies elaborated on the challenges by adding limited public awareness as the reason for the low state support for the initiatives aimed at increasing the share of RESs in the total amount of energy produced.

Notwithstanding the optimistic prospects offered by regional integration and renewable energy transitions, institutional and policy impediments pose considerable risks to the effective execution of Kosovo's energy objectives. A primary issue pertains to inadequate inter-agency coordination among ministries accountable for energy, environment, infrastructure, and economic development, which frequently function with overlapping responsibilities and restricted horizontal integration. The Organization for Economic Co-operation and Development (OECD) (2022) emphasizes that such fragmentation hinders policy coherence and the effective deployment of resources. Moreover, corruption risks, evident in opaque procurement procedures, political favouritism inside state-owned energy companies, and inadequate regulatory supervision, persist in undermining public confidence and reducing the legitimacy of reform efforts. The deficiencies in governance are exacerbated by restricted administrative and enforcement capabilities, especially within the Energy Regulatory Office and local authorities responsible for the implementation and oversight of energy

efficiency standards (Havrysh, Nitsenko and Hruban, 2022; Wang *et al*., 2024). In the absence of specific measures to enhance bureaucratic accountability, transparency, and regulatory independence, the prospective advantages of liberalization, tariff reform, and renewable integration may be compromised. Consequently, forthcoming initiatives must incorporate not just technological and economic factors but also institutional resilience and effective governance as essential elements of Kosovo's energy transition agenda.

Hence, the introduced findings are mainly consistent with the previously conducted research, emphasizing the fragility and fragmented nature of the Western Balkan energy system, which exacerbates energy poverty and inequality in the region. However, in contrast to previous research, which tends to focus on the entire Western Balkan region, this study focused on Kosovo's whose controversial political status encouraged some experts to examine the state energy system in Serbia's context. By adding to the academic discourse, this study emphasized the need for further research on Kosovo's energy system and strategies to modernize it.

Conclusions

The case study analysis revealed that after Yugoslavia's breakup in the early 1990s, the Republic of Kosovo's energy system faced a range of challenges, some of which persist to date. The fragmented and fragile system required considerable rearrangement to operate in line with the EU standards and become an integral part of the regional and pan-European markets. Based on existing industry reports, peer-reviewed journal articles, and other credible resources, the main challenges facing Kosovo's energy system include heavy reliance on lignite coal, low public awareness of the environmental and health issues caused by using coal as the primary energy source, energy price increases across Europe, and price volatility due to high uncertainty of the global energy market. However, the cost and benefit analysis suggested that the potential advantages outweigh the mentioned limitations, hence emphasizing the feasibility of modernising Kosovo's outdated and ineffective energy system.

The benefits examined in this case study included accelerated economic growth expressed in GDP; the growing demand for energy caused by Kosovo's industrialization and urbanization; liberalization of the national energy system aimed at improving the flexibility of the existing tariff system, as well as the quality and reliability of services provided; and participation in the EU-sponsored projects to ensure diversification of the national energy profile and shift towards RESs.

The Republic of Kosovo might take advantage of the detected benefits by applying a repertoire of interventions, which are either short medium, or long-term. In the short run, the country is recommended to facilitate the efficient use of energy to reduce the growing demand and ensure that the price increase does not affect the most vulnerable households. In the mid-term, the country is suggested to diversify from lignite, which now accounts for nearly 90% of all energy produced. The recommended diversification will enhance the energy system's resilience and alleviate some environmental pollution consequences. The mid-term interventions will bring the Republic of Kosovo closer to accomplishing its long-term tasks, including the transition to RESs. The accumulated evidence suggests that in some parts of Kosovo, the use of solar, hydro, and wind power

demonstrated its efficiency and ability to address a repertoire of economic, environmental, health, and social issues.

This study acknowledges limitations, including the limited use of sources to contextualize the emergence and development of Kosovo's energy system as an autonomous unit. Future research might focus on detecting and elaborating on the key milestones in the evolution of the national power system. Furthermore, little attention was paid to the socio-cultural side of increasing the efficiency of Kosovo's energy system. This deficiency can be addressed through qualitative studies, including observations, focus groups, and in-depth interviews, to gain an understanding of the community's perspective on integrating Kosovo's energy system into the regional and pan-European market.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*	*Author 4*
Conceived and designed the research or analysis	Yes	Yes	No	No
Collected the data	Yes	No	Yes	No
Contributed to data analysis & interpretation	No	Yes	Yes	Yes
Wrote the article/paper	Yes	Yes	Yes	Yes
Critical revision of the article/paper	Yes	Yes	Yes	Yes
Editing of the article/paper	No	No	No	Yes
Supervision	No	Yes	No	No
Project Administration	Yes	No	No	No
Funding Acquisition	No	No	No	No
Overall Contribution Proportion (%)	27	27	23	23

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Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
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